1. **Project Name:** **Advanced Nanoporous Composite Materials for Industrial Heat Applications**

2. **Lead Organization:** Lawrence Berkeley National Laboratory
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4. **Project Partners:** Anter Corporation, Thermal measurements and properties testing, Dr. Daniela Stroe, Laboratory Director

5. **Date Project Initiated and FY of Effort:** 8/1/2001, Second FY

6. **Expected Completion Date:** 9/30/2005

7. **Project Technical Milestones and Schedule**

Milestone	**Completion date**
● Survey and identify candidate materials	December 2001
● Produce gels of candidate materials and optimize drying processes	April 2002
● Compare monoliths, compacts, and additions	December 2002
● Complete thermal measurements	July 2003
● Develop thermal opacifing techniques	September 2003
● Tailor prototype materials for specific applications	September 2004
● In-use testing with industry	September 2005

8. **Past Project Milestones and Accomplishments**:

- Several candidate materials were identified that were compatible with glass melting and other high temperature industrial insulation and refractory applications. They included Cr_2O_3; various stoichiometries of Cr_2O_3 and Al_2O_3; and Cr_2O_3 and Al_20_3 with silica as stabilizer.

- Gels were produced using a variety of chemical pathways, initially using alkoxides of aluminum and chromium. Alcogels were formulated successfully using these starting compounds exhibited microstructured properties after prolonged exposures to high temperatures. The gels were successfully dried using both carbon dioxide and heavy alcohols as solvents.

- An unexpected benefit came from the discovery of a non-conventional route to the chromia/alumina gels. This allowed the use of inexpensive commodity chemicals instead of expensive alkoxide precursors. Preliminary calculations showed that the raw material costs dropped from $118 per pound to slightly over $2 per pound.

- We evaluated the preparation of advanced materials that were produced in monolithic and powdered forms as well as using them for additions into existing refractory materials. The monoliths were sufficiently low in density but material handling problems led to the choice of powdered materials that were then compressed into pellets. The powder process appears to be the best choice but further efforts are needed to reduce their density for use as high temperature insulation.

9. **Planned Future Milestones:**

- Thermal measurements were carried out in collaboration with Anter Corporation and the thermal testing laboratory at ORNL. Most of the initial thermal testing was completed but the effect of the radiant pacifying agents on high temperature thermal conductivity is still to be evaluated. Once the test procedures have been finalized, continued thermal measurements will be needed to characterize new and modified materials.

- Porous insulating materials at high temperatures exhibit significant radiant heat transfer due to their partial transparency. A significant effort for the rest of the current year will be to develop and test pacifying agents that are added to reduce the radiant heat transfer within the materials. In addition to improving thermal behavior through opacifiers, research will continue to evaluate methods to achieve lower density for improved thermal performance. In addition, we will evaluate alternative denser materials with sufficient strength to withstand direct mechanical use but are still much better insulators than conventional refractory lining materials. Further industrial partners will be sought to test new materials in real applications. Hopefully, the current economic downturn that has led to a sharp decrease in orders for advanced ceramics for high temperature applications will improve and more manufacturers will be interested in new advanced refractory materials.

- Next year the emphasis will be on tailoring the materials and processes developed to date to industry specific applications in thermal insulation and low conductivity refractory liners and boundaries. Refractory and insulation manufacturers and end users will be solicited for direct testing of these new microporous materials and for the incorporation of these materials into existing refractories.

- The materials will be tested directly in new and existing high temperature industrial process heat applications. With successful tests in hand, the preparation processes for advanced microstructured materials will be licensed to the refractory manufacturing industry.

10. **Issues/Barriers:** As pointed out above, several issues remain to be reconciled. New methods will be investigated to better control the density of the materials for insulation and refractory applications. Improved pacifying agents will be developed and incorporated into the microstructured materials to reduce the thermal conductivity of the materials.

11. **Intended Market and Commercialization Plans/Progress:** As mentioned above we will work with the refractory manufacturers and end use industries to further develop our materials for specific niches within the industrial process heat industries. These may include improved insulation in industrial hearth, tank, and pot furnaces as well as in regenerators, ports and crowns.

12. **Patents, publications, presentations:** Presentations: DOE/IHEA Materials Forum, ORNL, Feb. 5, 2003, IMF Program Review Meeting June 2002, Albuquerque, NM.